PERFORMANCE AND EMISSION CHARACTERSTISTICS OF EUCALYPTUS OIL AND GASOLINE BLEND IN FOUR STROKE MULTI CYLINDER PETROL ENGINE

A Thesis submitted in partial fulfillment
Of the requirements for the degree of

Bachelor of Technology
In
Mechanical Engineering
By

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CERTIFICATE

This is to certify that the thesis entitled, "**PERFORMANCE AND EMISSION CHARACTERSISTICS OF EUCALYPTUS OIL AND GASOLINE BLEND IN FOUR SROKE MULTI CYLINDER PETROL ENGINE**" submitted by **Pankaj Kumar (108ME042)** in partial fulfillment of the requirements for the award of **Bachelor of Technology degree** in **Mechanical Engineering** at National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any University/Institute for the award of any Degree or Diploma.

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ABSTRACT

Petrol engines are very popular from the time of their invention; most of the automobiles are run by these engines. Mainly because of its simplicity and easy operations they are the choices for a number of researches but due to lack of crude oil reserves and increasing price of petrol alternative fuels are coming to picture. Today Most of the alternative fuels are biomass derived and easily available. Many alternative fuels blends has been introduce in past and they gave very satisfying results. Therefore, in this project the eucalyptus oil which is high octane biomass derived fuel is blended with petrol 15% by volume Eu15 and used as fuel in four stroke multi cylinder petrol engine. The performance and emission characteristics of the engine were studied. The results show the reduction in consumption of fuel as the brake specific fuel consumption was found to decrease. The improvement in brake thermal efficiency is also observed. While the emission parameters were also improved, both HC and CO emissions were significantly reduces as the load was increasing.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

As the time passes, it is believed that the petroleum products and crude oil will be not enough and will be costly. Various researches are going on for the improvement of fuel economy of engines. However as the demand and availability for petrol and diesel is somewhat unbalanced and there is a need to balance since that is mainly happened due to enormous increase in number of vehicles. If the same situation continues then the scenario will be more disastrous and petrol and diesel will be more costly and limited. With increased use and the depletion of fossil fuels, today more emphasis is given on the alternate fuels.

There is an essential need of alternate fuels in a way or other. Today intensive search for the alternative fuels for both spark ignition (SI) and compression ignition (CI) engines and it has been found out that the biomass derived fuels are suited for the alternate fuels. In spark ignition engines fuels like eucalyptus oil and orange oil are the suitable substituents for the petrol. They can be blended with petrol over a wide range of percentage according to the requirement. Another reason for the need of alternate fuels for IC engines is the emission problems. Combined with other air polluting factors, the large number of automobiles is a major contributor to the air quality problems of the world. As these fuels cannot be run directly in the engines therefore these are blended with gasoline at various percentage. One of the main reasons for selecting these fuels is the similarity in the properties of these with gasoline and they are miscible with gasoline without any phase separation. The engines used for these blending or for alternate fuels are modified engines which were originally designed for gasoline fuelling. The eucalyptus oil can be used in spark-ignition engines with very little engine modification as a blend with gasoline. Since the octane number of eucalyptus oil is more than gasoline, so it enhances the octane value

of the fuel when it is blended with low octane gasoline. At the same time the compression ratio (CR) which is dependent on knock can be increased when these fuels are blended with gasoline.

1.2. AN OUTLOOK TO INDIAN AND GLOBAL PETROLEUM SCENARIO

1.2.1 INDIAN SCENARIO

In India the petroleum industry contribute almost 45 % as energy providing source. India's consumption (111.9 MMT in 2005-06) of petroleum products is only about 1/5th of world's average per capita consumption. Exceptionally high crude oil prices in the international market and an almost stagnant domestic crude oil production has caused oil consumption is expected to grow at the rate 2.4 percent respectively as against the world average of 1.4 percent.

1.2.2 GLOBAL OIL SCENARIO

World oil use is expected to grow from about 80 million barrels per day (mbpd) in 2003 to 98 mbpd in 2015 and 118 mbpd in 2030 as per Energy Information Administration (EIA), International Energy Outlook (IEO) 2006.

To meet the projected increase in world oil demand, total petroleum supply in 2030 will need to be 38 mbpd higher than the 2003 level of 80 mbpd. Also the prices of crude oil rise from $31 per barrel in 2003 to $57 per barrel in 2030, and oil’s share of total world energy use will falls from 39 percent to 33 percent.

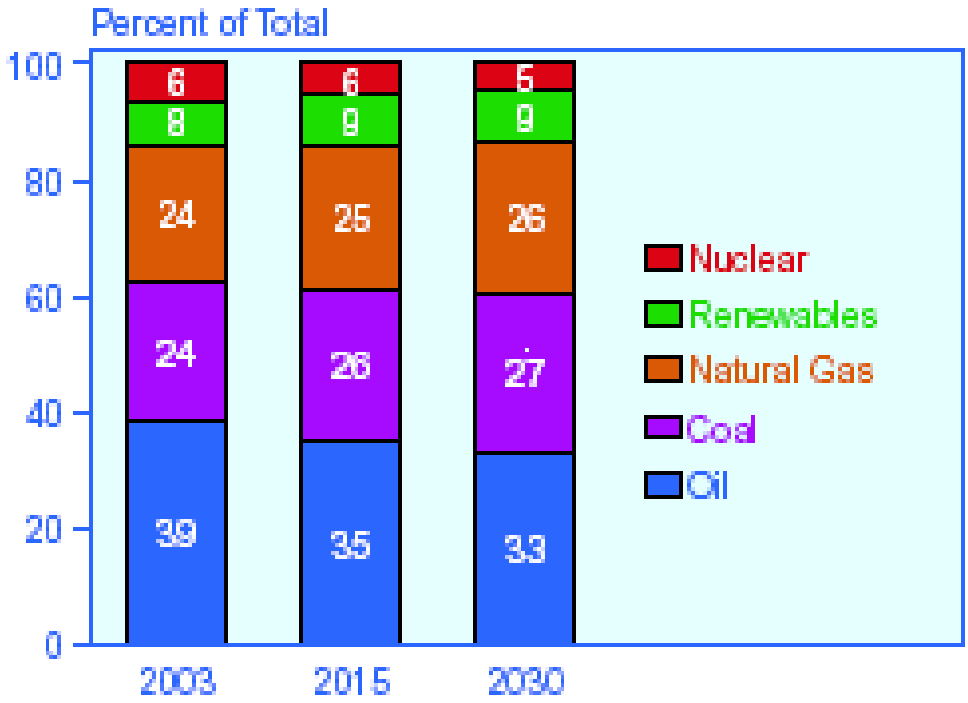

Figure 1: Oil share to the total energy production

1.3 TYPES OF FUELS

Basically there are three types of fuels on which an internal combustion engine can be run viz. liquid, gaseous and solid fuels.

- **Solid fuels** have very less practical applications mainly because of handling problems and disposing off the left over components. But they played a vital role during the initial stages of engine development.

- **Gaseous fuels** are considered to as ideal fuel and display very few problems when they are used in internal combustion engines because they mix with air very easily and give a significantly homogeneous mixture. They also suffer with the problem of handling and storage. Their principle applications can be seen in stationary power plants. Some of the gaseous fuels can be liquefied under pressure resulting in less storage volume but this type of arrangement is very expensive as well as risky.
- **Liquid fuels** are the derivatives of liquid petroleum and they are used in most of the modern internal combustion engines. The three principal commercial types of fuels are benzyl, alcohol and petroleum products. Today the petroleum products form the main fuels for internal combustion engines.

1.4 OBJECTIVES

1. An attempt has been made to replace the Gasoline in multi cylinder petrol engine with some percentage of Eucalyptus oil.
2. To study the performance parameters like brake thermal efficiency and brake specific fuel consumption at various loads.
3. To study the emission parameters mainly exhaust parameters like hydrocarbon emission, oxides of carbon (CO & CO_2) and oxides of nitrogen (NO_x).

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE SURVEY

Various researches which have been done in the past over a time of period came out to be very useful and informative while initiating the above research work.

- **POOLA R.B. et al. [2]** carried out an experiment in the year 1993 with 20% by volume of orange oil and eucalyptus oil were separately blended with gasoline brake thermal efficiency, exhaust emissions and combustion parameters were obtained. The experiment was conducted on small capacity (145.45 cc displacement volume, 4.3 KW at 5200 r.p.m), loop scavenged, air cooled, single cylinder, two stroke -ignition engines with a compression ratio of 7.4. It was found out that the performance fuel blends was better than gasoline fuel. Experiment was performed on two compression ratios viz. 7.4 &9 and improvement of 20.5% in brake thermal efficiency was obtained at 2 KW, 3000 r.p.m, over the normal gasoline engine. Along with this hydrocarbon and carbon monoxide emission were reduced. While comparing the two fuel blends eucalyptus oil blend provides the best results for brake thermal efficiency with low exhaust emissions.

- **TAMILVENDHAN.D et al. [3]** carried out the experimental study on the performance, emission characteristics of a methyl ester sunflower oil- eucalyptus oil on a single cylinder air cooled and direct injection diesel engine as an alternative fuel and the results which were obtained by the above test were compared with the results while running with

standard diesel fuel. When eucalyptus oil having low cetane number is mixed with methyl ester sunflower oil having high cetane number up to 50% results in increase in brake thermal efficiency by 2 to 3 percentage. The results also indicated the reduction of 37.5% in carbon monoxide emission for the MeS50Eu50 blend at full load while the hydrocarbon emissions were reduced at both low load and full load but considerably at full load that may be due to the complete combustion of the fuel blend.

- **M. SENTHIL KUMAR et al. (2001) [17]**, carried out experiment on th use of vegetables directly in compression ignition engines. Along with that Small quantities of orange oil were inducted along with air and ignited after compression. Methyl ester of Jatropha oil and diesel were also used as fuels for comparing the results with that of the vegetable oil.

- **PURUSHOTHAMAN K. et al. (2009) [6],** studied about the the performance, emission and combustion characteristics of a single cylinder, constant speed, direct injection diesel engine using orange oil as an alternate fuel and the results are compared with the standard diesel fuel operation. The results shows that the brake thermal efficiency is higher than that of diesel operation throughout the load variation.

- **DEVAN P K. et al. (2009) [10],** they worked on to find out the performance, emission and combustion characteristics of a DI diesel engine using poon oil-based fuels and poon oil and poon oil methyl ester are tested in blended forms They prepared th blend with

20% poon oil and 40% poon oil methyl ester separately with standard diesel. Results obtained show the reduction of CO and HC emissions.

- **MISRA R D et al. (2011) ,** carried out an experiment on a non edible straight vegetable oil blended with diesel in various proportions to evaluate the performance and emission characteristics of a single cylinder direct injection constant speed diesel engine.

CHAPTER 3

EUCALYPTUS OIL

AND

BLENDING

3.1 WHY BLENDING IS REQUIRED?

As the demand of petrol and petroleum products is getting increased day by day the petrol and diesel are becoming expensive and will be scarce in the future. The main reason for this situation is the increase in the number of vehicles and most of the crude oil is imported from other countries which control the larger oil fields. In order to make the situation look better various researches and experiments were done to replace the petrol and diesel with some suitable alternate fuel. Various fuels are found out to be potential candidates for both spark-ignition (SI) and compression ignition (CI) engines. When we specifically talk about spark-ignition engine (SI) biomass derived fuels having high octane value are the potential alternative fuel. It includes oils like orange oil and eucalyptus oil.

Blending is a process of mixing two fluids of almost same characteristics properties by volume. Gasoline is blended with eucalyptus oil 15% by volume. These two fuels are readily mixes and do not lead to phase separation and their properties are similar and eucalyptus oil is miscible with gasoline. The fuel blend (Eu15) is the replacement of petrol in the engine. Blending leads to less consumption of the petrol while operating at same conditions as that of standard petrol and it also leads to the improvement of brake thermal efficiency of the engine at the same time reduces the emission characteristics viz. CO emissions, HC emissions and NO emissions. It also improves the performance of the engine.

When eucalyptus oil which is highly volatile basically consist of cineole the major component of the eucalyptus oil, it decomposes easily at low temperature and due to that it release more

intermediate components immediately after its injection. This may be one of the reasons for the better performance of Eu15 than that of the standard gasoline operation. When eucalyptus oil is mixed with petrol the overall density of the fuel decreases and that leads to improved atomization, fuel vaporization and combustion. The reason may be the better utilization of heat energy and better air entertainment.

The presence of eucalyptus oil in the blend causes longer ignition delay and rapid combustion of the fuel blend. Actually during longer ignition delay engine allow more fuel before the starting of combustion process and releases more heat during premixed phase of combustion. Due to this the cylinders pressure rises and correspondingly the brake thermal efficiency of the engine.

3.2 PHYSICAL AND CHEMICAL PROPERTIES OF EUCALYPTUS OIL (HIGH OCTANE FUEL)

Eucalyptus oil is mainly extracted from the leaves of the eucalyptus tree. A very eucalyptus species, mainly mallees species produces the leaf oil. This oil is composed of mixture of volatile organic compounds like hydrocarbons, alcohols, aldehydes, keytones, acids, ethers and esters. 1-8 cineole is the active component of eucalyptus oil. Cineole is cyclic ether with empirical formula $C_{10}H_{18}O$ and systematic name 1,3,3-trimethyl1-2-oxabicyclo octane [3].

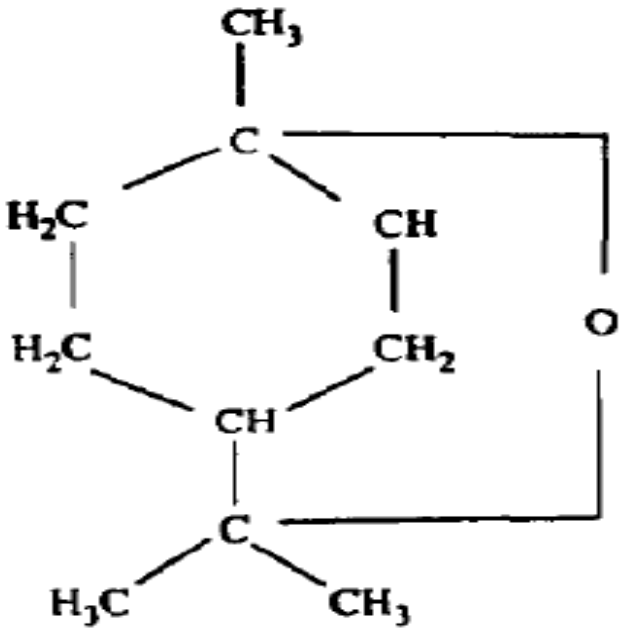

Figure 2: Chemical Structure of 1-8 cineole

3.2.1. Properties analysis

The properties of gasoline and eucalyptus oil are compared and are given in table1. It is seen that the properties of eucalyptus oil and gasoline are somewhat close and comparable.

Table 1: Properties of Gasoline and Eucalyptus oil

Properties	Gasoline	Eucalyptus oil
Formula	C_4 to C_{12}	$C_{10}H_{18}O$
Molecular weight	105	154
Composition (% Wt)	$C_{88}H_{15}$	-
Density (kg/m^3)	780	913
Specific gravity	0.78	0.918
Boiling point (^oC)	30-220	175
Viscosity (c St)	0.4	2.0
Latent heat of vaporization (kJ/kg)	350	305
Lower heating value (kJ/kg)	43,890	43,270
Flash point (^oC)	43	53
Auto ignition temperature (^oC)	300-450	300-330
Flammability limit (% vol)	1.4	0.8

CHAPTER 4

EXPERIMENTAL

SETUP

4.1 EXPERIMENTAL SETUP

A Four stroke multi cylinder petrol engine is used for performing the performance and emission characteristics tests using Eu15 blend as fuel. The engine was coupled to an eddy current dynamometer (Vibrometer) for torque and speed measurements. A gas analyzers is used for measuring the emission parameters in the engine exhaust. The speed is kept to be constant around 1200 rpm and the variable load test is to be conducted at constant engine speed, at every operating point values of the emission parameters has to be recorded. In the present investigation the high octane fuel viz. Eucalyptus oil is blended with gasoline in the proportion 15% by volume and the engine brake thermal efficiency, exhaust emission were evaluated.

Engine specifications:

Table 2: Specification of multi cylinder petrol engine

Parameter	**Value**
Engine Type	4-Stroke cycle, multi cylinder. spark ignition
Bore (mm)	84
Stroke (mm)	82
Compression ratio	8.5:1
Torque (N-m)	130
O/P, (kW)	55.2
Displacement (cc)	1817

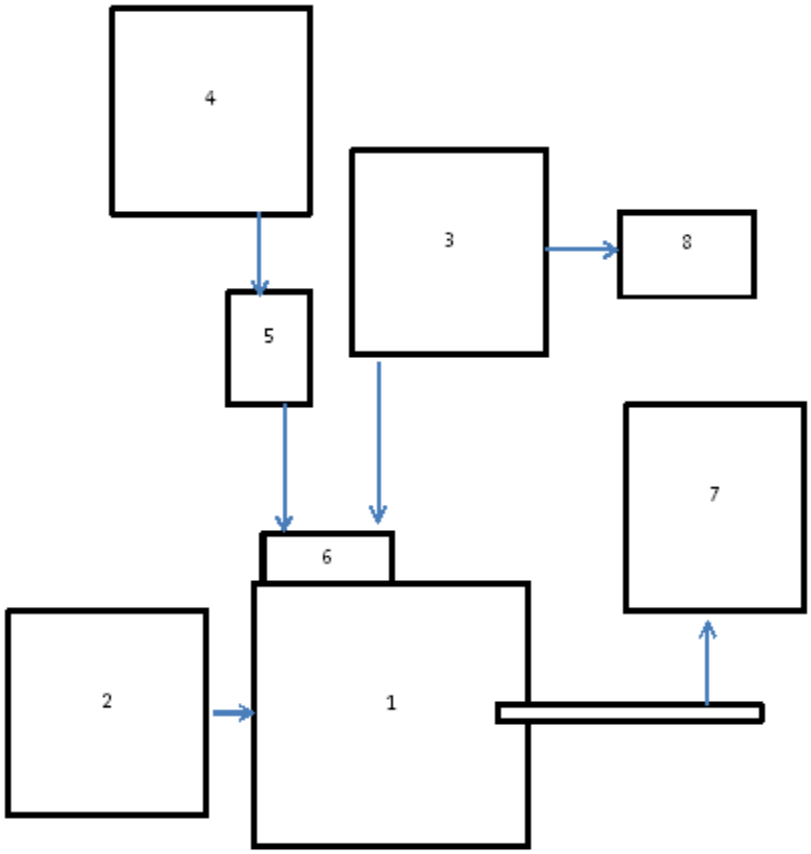

Fig3: Schematic diagram of Experimental set up

1. Four cylinder SI Engine
2. Dynamometer
3. Air tank
4. Fuel tank
5. Burette
6. Carburetor
7. Gas analyzer
8. Manometer

CHAPTER 5

RESULTS

AND

DISCUSSION

5.1 PERFORMANCE CHARACTERISITCS

The engine performance is indicated by the term efficiency η.. The heat energy which is converted to power is called indicated power, ***ip*** it is utilized to drive the piston. The useful energy available at the shaft is called brake power ***bp***. The fuel consumption characteristics of an engine are generally expressed in terms of specific consumption in kg of fuel per kilowatt-hour. It is an important parameter that reflects how good the engine performance is. The relationship between speed, power developed and specific fuel consumption determines the performance of an engine.

5.1.1 BRAKE THERMAL EFFICIENCY

It is the ratio of energy in the brake power, BP, to the input fuel energy in appropriate units. The brake thermal efficiency gives an indication of the output generated by the engine as compared to the heat supplied to the engine. This heat is derived from burning of the fuel.

η_{bth}= BP/ ((Mass of fuel)/s * calorific value of fuel),

Where η_{bth} is the brake thermal efficiency.

The fig. gives the comparison between the brake thermal efficiency of the engine when run with Standard gasoline fuel and when the eucalyptus oil blended with gasoline Eu15 .The brake thermal efficiency is plotted as a function of brake power (KW). It has been observed that the brake thermal efficiency increases when the engine is run with Eu15.

The increase in the brake thermal efficiency may be of eucalyptus oil which is highly volatile basically consist of cineole the major component of the eucalyptus oil, it decomposes easily at low temperature and due to that it release more intermediate components immediately after its injection. This may be one of the reasons for the better performance of Eu15 than that of the standard gasoline operation. When eucalyptus oil is mixed with petrol the overall density of the fuel decreases and that leads to improved atomization, fuel vaporization and combustion. The reason may be the better utilization of heat energy and better air entertainment.

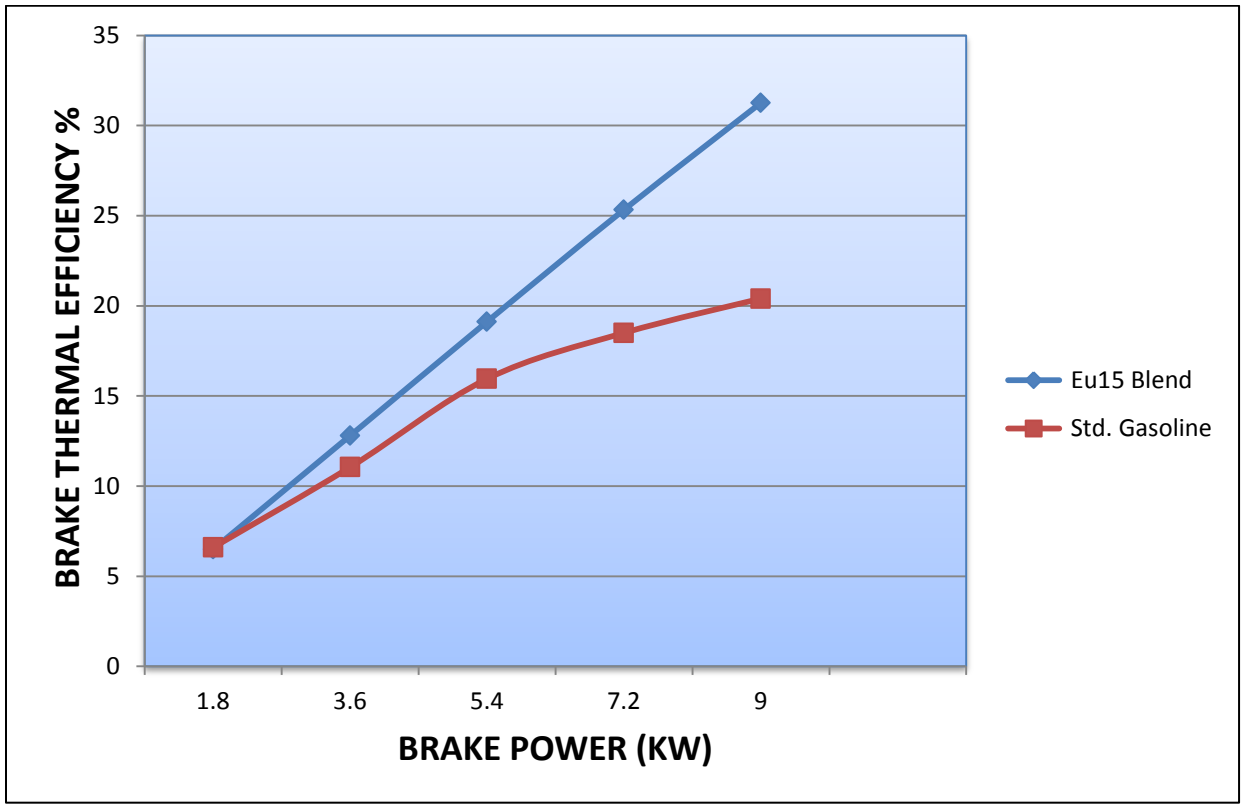

Figure 4: Variation of break thermal efficiency with brake power BP for Eu15 Blend and Std. petrol

5.1.2 BRAKE SPECIFIC FUEL CONSUMPTION

The fuel consumption characteristics of an engine are generally expressed in terms of specific fuel consumption in kilograms of fuel per kilowatt-hour. It is an important parameter that reflects how good the engine performance is. It is inversely proportional proportional to the thermal efficiency of the engine.

Break specific fuel consumption bsfc is mass of fuel consumed per unit **brake power BP**

bsfc = m_f / BP

Where **m_f** (kg/h) is the mass of fuel consumed per unit time and **BP** is the brake power (KW).

The graph shows the variation of the brake specific fuel consumption (kg/h) versus brake power (KW) when petrol is used as fuel and it is compared with brake specific fuel consumption when Eu15 is used as fuel. The bsfc of the Eu15 blend was lower than that of the std. petrol.

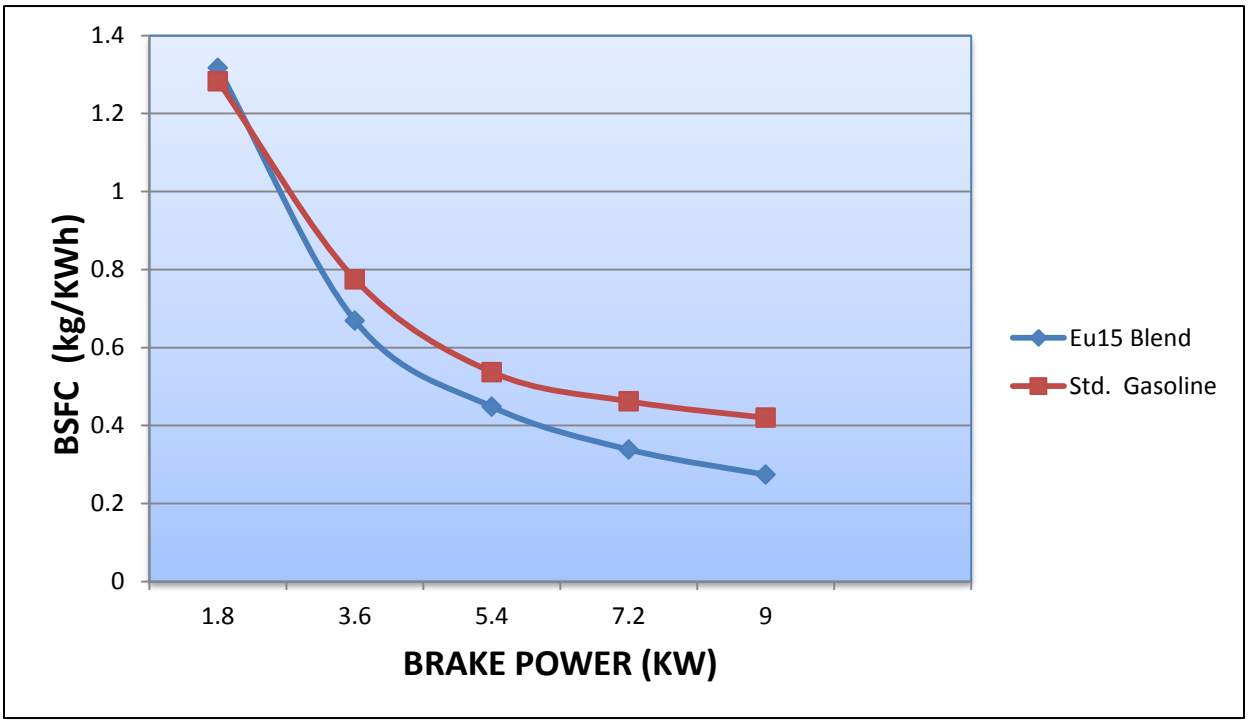

Figure 5: Variation of brake specific fuel consumption bsfc with brake power BP for Eu15 blend and Std. Petrol

5.2 EMISSION ANALYSIS

While running any internal combustion undesirable emissions are generated during the combustion process emphasis is given on reducing the emission coming out of an engine. The emissions which are exhausted into the surrounding pollute the atmosphere and causes various problems like global warming, acid rain, smog, odours and respiratory hazards. Usually running an engine with petrol as fuel emission parameters are not specifically ideal that results in more emission of unburnt hydrocarbon HC and carbon monoxide CO and oxide of nitrogen NO_x .

Engine emissions are classified into two categories:

1) Exhaust emissions and
2) Non exhaust emissions

Exhaust emissions:

As mentioned above exhaust emissions are

- Unburnt hydrocarbon HC
- Oxides of carbon
    a) Carbon monoxide CO
    b) Carbon dioxide CO_2
- Oxides of nitrogen NO_x

The above emissions are common to both SI and CI engines. The main non exhaust emission is the un burnt hydrocarbons from fuel tank and crankcase blowby.

5.2.1 HYDROCARBON EMISSION

In an SI engine the exhaust gases leaving the combustion chamber contain 6000 ppm of hydrocarbon components about 1-1.5% of fuel. About 40% of this is unburned components of the fuel. Hydrocarbon emissions are different for different gasoline blends, depending on original fuel components. At the same time combustion chamber geometry and engine operating parameters also influence the HC emissions.

The main reason for the HC emission is the absence of sufficient oxygen to react with all the carbon present in a fuel-rich mixture resulting in high levels of HC and CO in the exhaust products. This mainly occurs during the starting conditions when air-fuel mixture is very rich and if the air-fuel mixture is kept too lean then there will be poor combustion again resulting in HC emissions.

The causes for hydrocarbon emissions in SI engines are:

- Incomplete combustion
- Leakage past the exhaust valve
- Flow of fuel between the piston, piston rings and cylinder walls.
- Valve overlap
- Deposition of fuel on walls
- Oil on combustion chamber walls

The incomplete combustion which is the prime reason for the HC emissions occurs due to two reasons:

I. Improper mixing

II. Flame quenching

The figure shows the variation of hydrocarbon HC emissions with brake power BP. Hydrocarbon emissions are generally lower as compared with normal gasoline fuel. Eu15 blend shows the reduction in HC emissions over the entire range of engine operations particularly at higher brake powers. The reason for the less HC emission is due to equivalence mixture ratio and easily decomposition of eucalyptus oil gives more intermediate compounds and presence of oxygen in cineole which is the main component of eucalyptus oil results in availability of more oxygen for carbon to react causing less HC emissions.

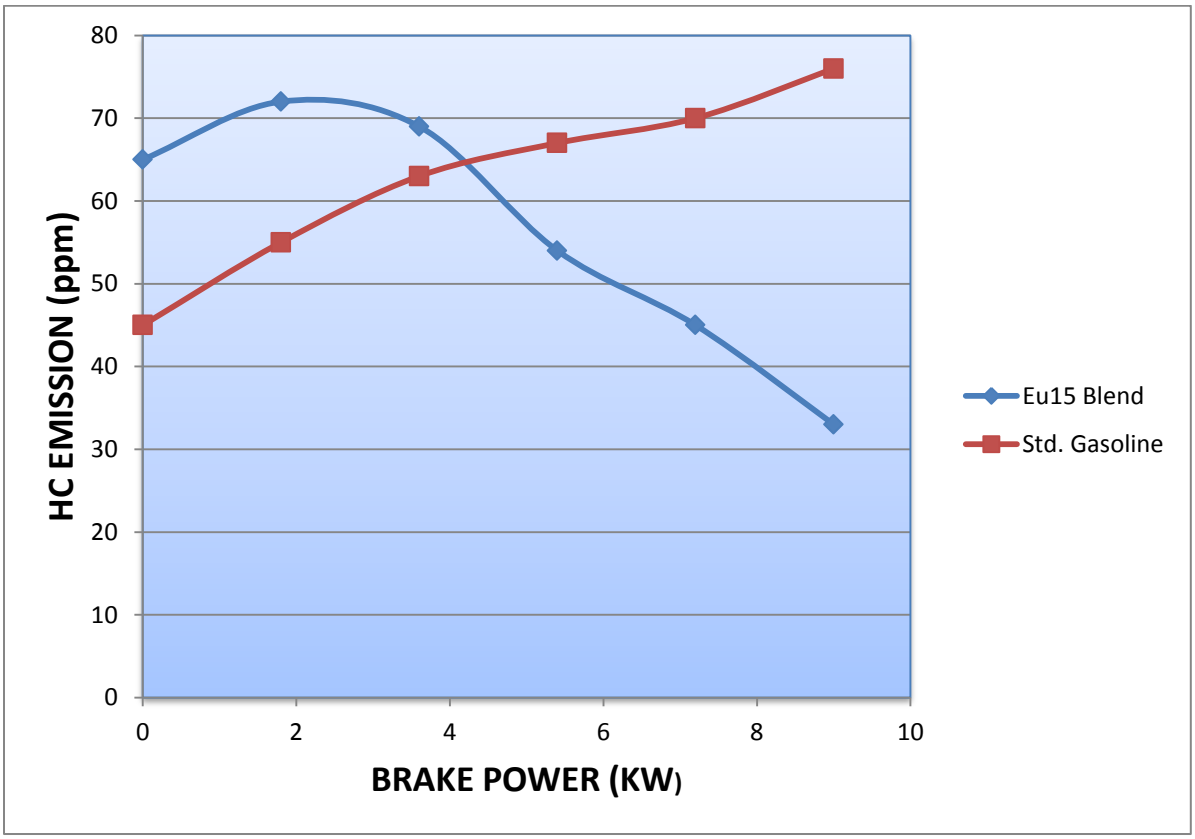

Figure 6: Variation of HC emissions with brake power BP. for Eu15 blend and Std. Petrol

5.2.2 CARBON MONOXIDE EMISSION

The graph shows the CO emission of Eu15 blend at various brake power output. It is found out that at low power output the CO emissions are significantly reduced but at higher loads the CO emissions decreases significantly. The reason for low CO emission may be the enrichment of oxygen in eucalyptus oil principle component cineole which increases the production of oxygen and promotes the further oxidation of CO during the engine exhaust process.

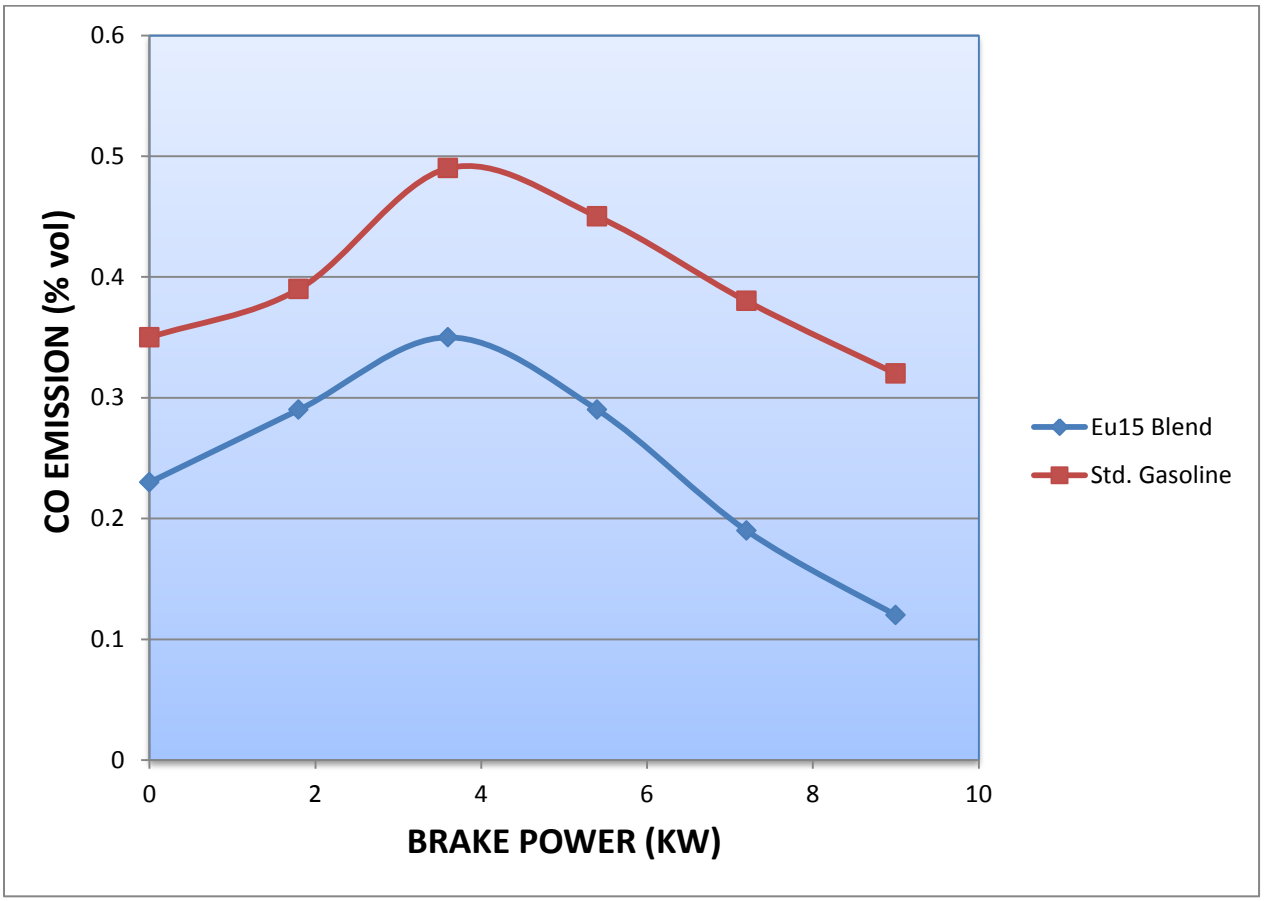

Figure 7: Variation of carbon monoxide CO with brake power BP for Eu15 blend and Std. Petrol

5.2.3 OXIDES OF NITROGEN (NO) EMISSION

The results for the variations of NO_x emission for Eu15 blends for different loads are shown in the figure. The NOemissions were continuously increasing as the load increases because of presence of oxygen in eucalyptus oil and the oxygenated fuel blends usually causes an icrease in NO emission. During complete combustion of the fuel high combustion temperature is achieved which results in higher NO formation. Another reason for rise in NO emission is due to longer ignition delay caused by eucalyptus oil and releases more heat during the premixed phase of combustion.

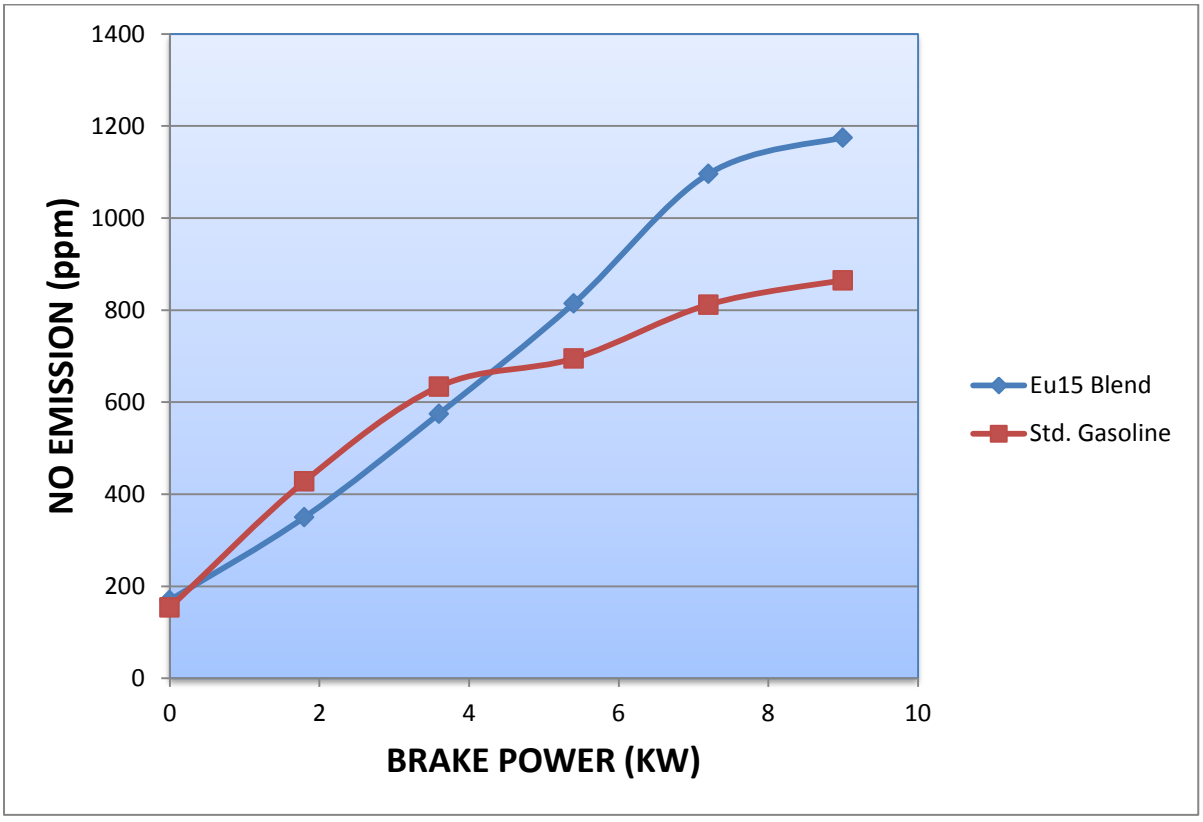

Figure 8: Variation of NO emission with brake power BP for Std. petrol and Eu15 blend

5.2.4 CARBON DIOXIDE (CO_2) EMISSION

The figure gives the variation of carbon dioxide emission with brake power when Eu15 is used as fuel. The carbon dioxide emission is found to increase at all power outputs when Eu15 fuel is used. The results show the increases in CO_2 emission as the power output increases as compared with the std. gasoline operation.

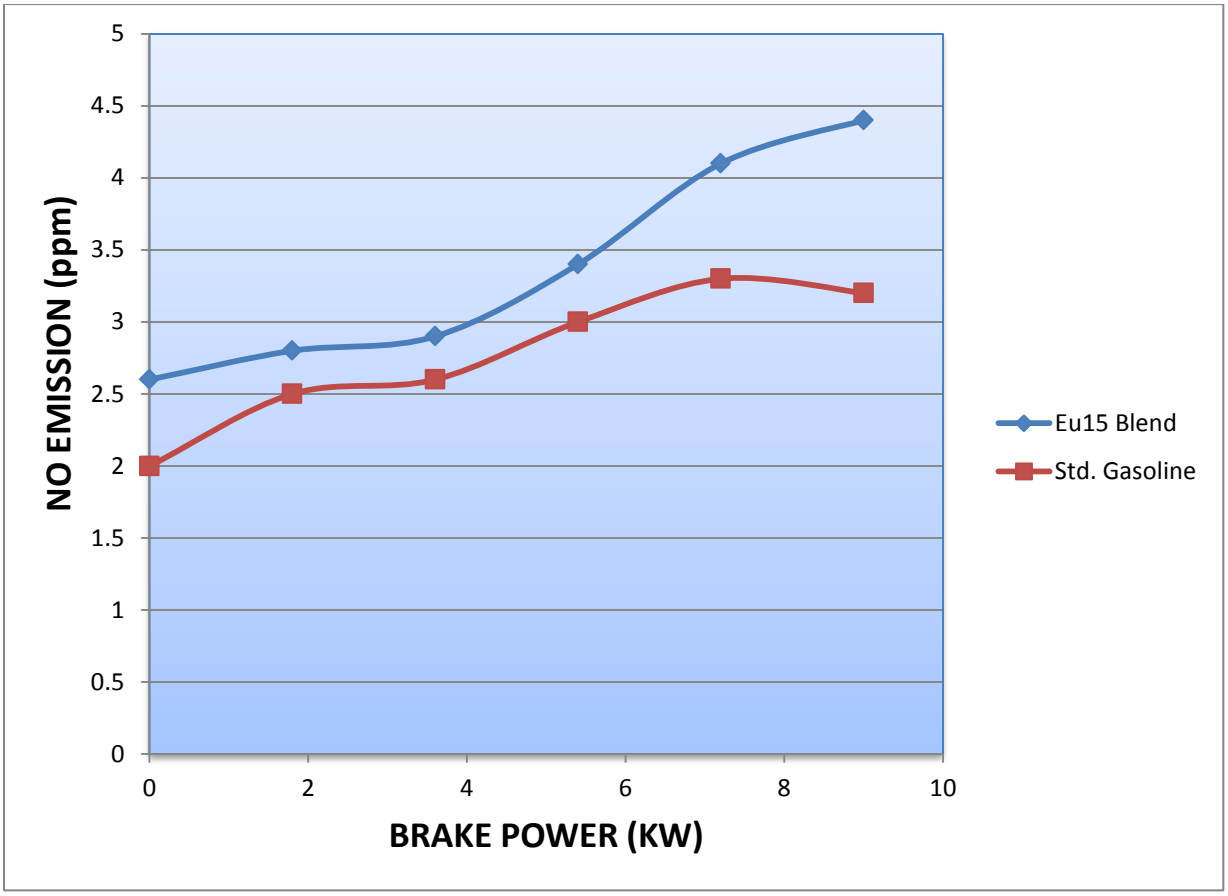

Figure 9: Variation of CO_2 emissions with brake power BP for Std. petrol and Eu15 blend

CHAPTER 6

CONCLUSION

6.1 CONCLUSIONS:

Eucalyptus oil is blended with petrol and petrol engine was run with this fuel .Performance and emission characters were found out and concluded as follow:

- Brake thermal efficiency has been improved by using Eu15 blend. The maximum improvement in brake thermal efficiency is obtained at higher brake power (9 KW). The BTE is 31.26% at full load.

- Brake specific fuel consumption bsfc is found to decrease as the load increases. At full load bsfc is lowest and found out as 0.2741.

- The improvement in the brake thermal efficiency and brake specific fuel consumption may be of eucalyptus oil which is highly volatile basically consist of cineole the major component of the eucalyptus oil, it decomposes easily at low temperature and due to that it release more intermediate components immediately after its injection. This may be one of the reasons for the better performance of Eu15 than that of the standard gasoline operation

- While studying the emission characteristics maximum improvement is seen. At low power outputs the HC emission is considerably more but as the load increases the reduction in HC emissions can be seen.

- From the graph it can be seen that at medium and low loads CO emissions of the blend is not much impressive, but CO emission of the blend significantly decreases at full load. The lowest value obtained for CO emission is 0.12 % vol at full load..

- At the same time when HC and CO emissions are reduced the CO_2 and NO_x emissions are found to be increasing as the load increases. The reason for increase in these two parameters may be because of presence of oxygen in eucalyptus oil and the oxygenated fuel blends usually causes an increase in NO_x emission. During complete combustion of the fuel high combustion temperature is achieved which results in higher NO_X and CO_2 formation.

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